Journal of Environmental Management 242 (2019) 131–141

Contents lists available at ScienceDirect

Journal of Environmental Management

journal homepage: www.elsevier.com/locate/jenvman

Research article

Role of financial development, economic growth & foreign direct investment in driving climate change: A case of emerging ASEAN

Muhammad Ali Nasir[a,b,*], Toan Luu Duc Huynh[b,c], Huong Thi Xuan Tram[b]

[a] Leeds Beckett University, United Kingdom
[b] School of Banking, University of Economics Ho Chi Minh City, Viet Nam
[c] WHU - Otto Beisheim School of Management, Vallendar, Germany

ARTICLE INFO

Keywords:
ASEAN
Economic growth
Pollution heavens hypothesis (PHH)
Environmental kuznets curve (ECK)
Emerging economies
Financial development
FDI
CO2 emission
FMOLS
DOLS*JEL classification:*
F14
F15
F43
E31
Q41
Q43

ABSTRACT

In the context of remarkable economic growth and financial development in the emerging economies of East Asia, this paper attempts to shed light on the ecological consequences (CO2 emission) of economic growth, foreign direct investment and financial development in the selected ASEAN-5 economies. Drawing on the data from 1982 to 2014, we employed a set of quantitative techniques for panel data analysis which entailed Dynamic Ordinary Least Squares (DOLS) and Fully Modified OLS (FMOLS) approaches. Our findings indicate that financial and economic development, as well as FDI, have a statistically significant long-run co-integrating relationship with environmental degradation (CO^2 emissions) in the under analysis economies. It showed that in ASEAN-5 countries, economic growth, financial development and FDI leads to an increase in environmental degradation. The quadratic term for economic growth showed a negative impact on environmental degradation i.e. Environmental Kuznets Curve (EKC). Our key findings manifest and emphasise the importance of appropriate policies for more inclusive economic and financial development and sustainable foreign direct investment which does not impede on the environment.

1. Introduction

The 21st century is marked as the Asian Century and a manifestation of this is prima evident in the fact that the emerging economies of Asia have been shouldering the global growth since the Global Financial Crisis (GFC) of 2008. In this regard, the Association of Southeast Asian Nations (ASEAN) has appeared as a significant economic block. As it stands, the ASEAN Economic Community (AEC) comes as a market of over US$ 2.6 trillion and a population of over 622 million growing at an impressing growth rate of around 5.2 and 4.9% in the second and third quarters of 2018 (FocusEconomics, 2018). Nonetheless, the forecast shows steady growth ahead for the AEC. In fact, according to the McKinsey Global Institute (MGI) report, ASEAN economies are among the world's outperforming emerging economies with a positive prospect of long-term growth (Das and Lin, 2018). While the economic growth and social progress in the ASEAN region are commendable, it is important to consider the ecological and environmental consequences of it. The literature on the economic growth and environmental degradation is mixed and the focus of a number of studies has been on the contrast between the short and long terms consequences of economic growth. Specifically, the notion that despite degradation of the environment in the short-run the economic growth can improve the environmental quality in the long-run. A phenomenon often referred as the Environmental Kuznets Curve (EKC).[1] However, the empirical evidence on this aspect of economic growth and environment entails mixed findings. For instance, Lindmark (2002), Lantz and Feng (2006), Caviglia-Harris et al. (2009), Narayan and Narayan (2010), Song et al. (2013), Onafowora and Owoye (2014), Apergis (2016) and Atasoy (2017) report contrasting results in different countries. One may argue that there could be differences between the developed and developing countries, yet such an assertion would be oversimplification as the empirical evidence suggests that there are

* Corresponding author. Economics, Analytics & International Business Group, Leeds Business School, Leeds Beckett University, The Rose Bowl, Portland Crescent, Leeds, LS1 3HB, UK.
E-mail addresses: m.a.nasir@leedsbeckett.ac.uk, m.a.nasir@ueh.edu.vn (M.A. Nasir).

[1] See, Grossman and Krueger (1991) and Shafik (1994) among the initial contributors.

https://doi.org/10.1016/j.jenvman.2019.03.112
Received 1 January 2019; Received in revised form 22 March 2019; Accepted 25 March 2019
Available online 25 April 2019
0301-4797/ © 2019 Elsevier Ltd. All rights reserved.

considerable differences even within the developed and developing countries (see, Al-Mulali and Ozturk (2016), Özokcu and Özdemir (2017) and Shahbaz et al. (2018). Concomitantly, it requires conducting in-depth analysis, specific to the economies in question, before one can draw a conclusion on the ecological and environmental consequences of economic growth in the ASEAN region.

Parallel to the economic growth, a crucial aspect is the growth of the financial sector or financial development. In fact, the economic and financial growth and stability are logically and legitimately perceived to be *two side of a coin* (Borio, 2011; Nasir et al., 2015). Although the nexus between the financial and economic stability has been emphasised long ago by various scholars (Bagehot, 1873; Gurley and Shaw, 1960; Goldsmith, 1969; McKinnon, 1973; Shaw, 1973; and Minsky, 1974, 1982; and Kindleberger, 1978) the GFC revived and reignited the debate on the role of financial development in the economic growth and development (Borio, 2011; Nasir et al., 2015). Concomitantly, some scholars argued that the role of the financial sector in the economy should be seen in a more holistic manner (Beck, 2012, Nguyena et al., 2017). There is also an important ecological aspect of finance (Grafton et al., 2004; Campiglio, 2016; Ackerman, 2017; Leimbach et al., 2018; Richardson, 2018; Yuan and Gallagher, 2018). Therefore, despite the recognition of financial development as an important factor for economic growth, it is also vital to consider this nexus more broadly and bring into account the social and ecological consequences of financial development which is one of the aspects the subject study is focusing on, specifically in the context of ASEAN region.

Similar to the literature on the finance-growth nexus, the literature on the role of finance in environmental degradation (or improvement) is also interesting but contrasting and hence inconclusive (see for instance, Tamazian and Rao, 2010; Ozturk and Acaravci, 2013; Shahbaz et al., 2016a, 2016b; Bekhet et al., 2017; Salahuddin et al., 2018). On this aspect, Zhang (2011) argued that the nexus between financial development and energy consumption can be explained by three channels. According to the first channel, the financial development results in the increase in the FDI and economic growth which consequently leads to an increase in the consumption of energy. Secondly, there is an increase in credit creation due to efficient financial intermediation which leads to an increase in the usage of energy-intensive goods and services. In the third channel, financial development leads to more investment which also increases the consumption of energy and hence, environmental degradation (Zhang, 2011). Hence, it is worth acknowledging that in the finance-environment nexus, the finance-led economic growth plays a crucial part. As the evidence on the finance-growth nexus suggests that the financial development is a major catalyst of economic growth (Soukhakian, 2007a, b; Katircioglu, 2012), it intuitive to expect that this may also have ecological implications. Specifically, real income growth resulting from financial development can lead to additional energy demand and investment in the energy sector which then affects the environment (Katircioglu and Taspinar, 2017; and Cetin and Ecevit, 2017). On the positive side, in a later study, Chang (2015) argued that financial development may offer more opportunities to develop the renewable energy sector by providing more funds to innovative firms. Nonetheless, the technological innovation and efficiency accompanied by FDI can help to reduce energy consumption. However, we are to see which channel of financial development rules the roost and especially, whether the financial development leads to improvement or degradation of the environment in the under analysis ASEAN region. Nonetheless, we are employing a more inclusive approach to measure the financial development and structure by incorporating not only the domestic credit creation but also the development of equity market and issuance of debt (international indebtedness) of the underlying economies.

The overarching evidence on the FDI role in environmental degradation is also inconclusive and contrasting. This inconclusiveness and contrast is a manifestation of the fact that theoretically there are three key dimensions of the nexus between FDI and environmental degradation. These include pollution-haven, pollution-halo and scale-effect hypothesis. According to the pollution-haven hypothesis the inwards FDI attracted by the weak regulatory environment in the host country leads to degradation of the environment (ColeFredriksson, 2009: Naughton, 2014). On the contrary, the pollution-halo hypothesis suggests that FDI by the multinational and transnational enterprises leads to the application of global environmental practices and standards in the host country as well as the transfer of green technology. In a nutshell, whether the FDI decreases or increases environmental degradation is contingent on whether pollution-haven or pollution-halo factor dominates. Nonetheless, the third aspect of FDI that is scale-effect hypothesis is also too important to condone. In this channel, the FDI leads to a significant increase in the industrial output of the host country which leads to an increase in the pollution and environmental degradations (Pao and Tsai, 2011; Rezza, 2013). Given that the ASEAN countries have been attracting a huge influx of FDI and along with the substantial economic growth, the financial sector has also been going through growth and development, it is intriguing to investigate the ecological consequences of these factors. The recent estimates suggest that the FDI flows to the ASEAN have been continuously increasing each year reaching an all-time high of US$137 billion in 2018 and are also expected to reach US$200 by 2025 (ASEAN Investment Report, 2018). Keeping this in context, we aimed to analyse the implication of economic growth, FDI and financial development for environmental degradation in ASEAN countries while drawing on the empirical data from 1982 to 2014. In terms of originality and contribution to the existing evidence and debate on the subject, this study first analyses the ecological and environmental implications of rapid economic growth in the ASEAN region, in both short and long run by exploring the aspect of EKC. Second, the subject study analyses the ecological and environmental implications of financial development for the ASEAN region while employing a more inclusive approach to financial development which entails three dimensions of financial development including domestic credit creation, development of equity market and international debt issuance of indebtedness economies. Third, in the context of an unprecedented influx of FDI in recent years, this study analyse the ecological and environmental implication of FDI for the ASEAN region. In so doing, we employed a set of quantitative techniques for panel data spanning from 1982 to 2014, including Dynamic Ordinary Least Squares (DOLS) and Fully Modified OLS (FMOLS) approaches. Our findings indicate that financial and economic development, as well as FDI, have a statistically significant long-run co-integrating relationship with environmental degradation (CO_2 emissions) in the under analysis economies. It showed that the in ASEAN-5 countries, the economic growth, financial development and FDI leads to an increase in the environmental degradation. The quadratic term for economic growth showed a negative impact on the environmental degradation i.e. Environmental Kuznets Curve (EKC). Our key findings manifest and emphasise the importance of appropriate policies for more inclusive economic and financial development and sustainable foreign direct investment which does not harbour adverse ecological consequences for the ASEAN economies.

The paper proceeds as follows: Section 2 briefly reflects and acknowledges the existing evidence on nexus between economic growth, financial development, FDI and CO_2 emissions. Section 3 presents the empirical framework and details on the dataset. Section 4 presents and discusses the empirical findings which will lead to the conclusion and discussion of policy implications in Section 5.

2. Literature review

This study is focusing on the ecological implication of economic growth, financial development and FDI, concomitantly, for the sake of coherence we can divide the literature into three aspects. To start with we look at the evidence on the economic growth and environmental degradation.

2.1. Economic growth and environment nexus

Economic growth is one of the prime objectives of macroeconomic policymaking, particularly since WWII (Raworth, 2017). The same holds true for the ASEAN economies. Yet, an important aspect which gained global attention in the last few decades is the ecological consequences of economic growth. On this aspect, a number of studies investigated the impact of economic growth on environmental degradation and often focused on the notion of the Environmental Kuznets Curve (EKC). According to the EKC, there is an inverted U-shaped relationship between economic growth and environmental degradation and hence, in the short-run, the economic growth contributes to the degradation of the environment, however as the countries reach the higher level of income this relationship goes inverse and economic growth starts to have a positive impact on the environment. Following the initial contribution on the nexus between economic and environment in the context of EKC by Grossman and Krueger (1991) and Shafik (1994), a number of studies have empirically tested this nexus. For example, in their study on the UK, Fosten et al. (2012) reported significant evidence of EKC. Furthermore, they found an asymmetric adjustment of temporary disequilibrium from the long-run EKC which they associated with the presence of strong environmental regulation in the UK. Perhaps, this is an aspect which could be of interest to the emerging economies such as ASEAN. In another study, Esteve and Tamarit (2012) focusing on the Spanish data argued that although the EKC may not follow a strict inverted U-shaped pattern, there is evidence that in the long run, the economic growth leads to a reduction of CO2 emissions and hence environmental improvements. However, in a later study which was also focusing on Spain, Sephton and Mann (2013) argued that in fact there is a long-run non-linear attractor that draws emissions and per capita income together and there is also an asymmetric adjustment. Similarly, Tiwari et al. (2013) and Sinha and Shahbaz (2018) reported a short, as well as a long-run relationship between economic growth and environmental degradation. However, on the contrary, while focusing on the Indian economy Ghosh (2010) reported lack of evidence on the existence of a long run relationship between economic growth and emission. Similarly, Pal and Mitra (2017) analysing Indian as well Chinese data failed to find significant evidence of EKC, yet on the contrary, Brajer et al. (2009) reported significant evidence of EKC in China. There is also a strand of literature which focused on multiple countries. For instance, employing the data of 15 OECD countries,[2] Apergis (2016) reported that although there was overarchingly evidence of EKC, however, it was not the case in all of the countries. Likewise, a study by Sinha et al. (2017) reported the presence of rather an N-shaped EKC in N-11 countries.[3] In another study which drew on the panel data from 27 developed countries, Al-Mulali and Ozturk (2016) reported significant evidence of EKC relationship. Similarly, in a study on Arctic countries, Baek (2015) reported that there was very little evidence of the existence of the EKC in the Arctic countries. In another remarkable study, Onafowora and Owoye (2014) analysed the notion of EKC in the selected economies of Brazil, China, Egypt, Japan, Mexico, Nigeria, South Korea, and South Africa indicate. However, they could only find the evidence of EKC in Japan and South Korea which were the only developed countries in their dataset. The led Shahbaz et al. (2018) argued that the stage of the development of a country may also influence the presence of EKC. However, a study by Narayan and Narayan (2010) focusing on 43 developing countries reported although there was evidence of EKC in the South Asian and Middle Eastern countries, on the whole, there were mixed and contrasting results. This implies that there could be regional heterogeneities as well and hence, one size does not fit all. Perhaps comprehensive studies by Caviglia-Harris et al. (2009) on 40 countries and Özokcu and Özdemir (2017) on 52 developing and 26 OECD countries, reported that there is no significant evidence of EKC. They argued that continued economic growth cannot lead to environmental improvement. Most recently, Shahbaz and Sinha (2019) conducted an inclusive survey of literate and concluded that the results of EKC are inconclusive and are contingent on the contexts, time period, explanatory factors and choice of empirical approach. These findings have profound importance for the ASEAN countries and particularly in the context of the remarkable growth they have achieved and projected to achieve in the year ahead. It also implies a gap in the existing body of knowledge which the subject study is aimed to address.

2.2. Financial development and environment nexus

Financial stability is vital for economic stability and by the same logic, a well-functioning and efficient financial sector facilitates economic growth, (see Soukhakian, B. (2007), Soukhakian, N. (2007) and Katircioglu (2012)), it intuitive to expect that this may have ecological implications. However, the positive role of financial sector development in enhancing economic growth can also increase the consumption of energy and concomitantly have unintended ecological consequences (Sadorsky, 2010, 2011; Shahbaz et al., 2012a, 2013c, 2017c, 2018, 2012b; Islam et al., 2013; Katircioglu and Taspinar, 2017; Cetin and Ecevit, 2017). The empirical evidence on the nexus between financial development and environmental degradation is mixed and contrasting. For instance, there are also a number of studies which suggest that the financial sector development can improve environmental quality. Among the earlier contributors, Tamazian et al. (2009) analysing the BRICS economies reported that financial development can reduce environmental degradation. Similarly, in their study focusing on 24 transition economies, Tamazian and Rao (2010) reported that financial liberalisation can lead to lowering CO2 emissions and hence improves environmental quality. Later, studies by Jalil and Feridun (2011) on China, Shahbaz et al. (2013c) on Malaysia and South Africa, Abbasi and Riaz (2016) on Pakistan, Dogan and Seker (2016) on top countries listed in the renewable energy attractiveness index and most recently Shahbaz et al. (2018) on France, reported positive ecological contributions of financial development. On the contrary, there are a considerable number of studies which reported that in fact financial development negatively affects the environment by increasing carbon emission. For instance, Zhang (2011) on China, Shahbaz et al. (2013c) on Indonesia, Javid and Sharif (2016) on Pakistan and Salahuddin et al. (2018) on Kuwait reported that the financial development has negative ecological consequences. Interestingly, there are also a considerable number of studies which reported that in fact there is no significant relationship between financial development and environmental degradation. For instance, Ozturk and Acaravci (2013) on Turkey, Omri et al. (2015) on MENA countries, Bekhet et al. (2017) on GCC countries, Charfeddine and Khediri (2016) on UAE and, Çoban and Topcu (2013) on EU countries reported neutral and mixed results. This implies that it will not be cogent to generalise the findings of existing evidence to the subject economies of ASEAN which have also been going through rapid economic and financial development. Nonetheless, it also indicates the caveat in the existing body of knowledge. To reiterate, we are also looking at the financial development in a more inclusive manner by incorporating the credit creation as well as equity market and international indebtedness of economies which adds to the debate on the subject. Keeping that in context, we are analysing the implication of this economic and financial development and its ecological consequences for ASEAN.

[2] These include 14 European countries i.e. Austria, Belgium, Canada, Denmark, Finland, France, Italy, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, and UK and USA.

[3] N-11 or Next 11 includes Bangladesh, Egypt, Indonesia, Iran, Mexico, Nigeria, Pakistan, the Philippines, Turkey, South Korea, and Vietnam.

2.3. FDI and environment nexus

The third crucial nexus the subject study is exploring is the nexus between FDI and Environment. In the context of the recent development in the ASEAN region and remarkable increase in the Flows of FDI which are also expected to further increase in the years ahead (ASEAN Investment Report, 2018), it is important to account for the ecological consequences of such huge inflows of FDI for the region. As acknowledged in the beginning of this treatise, theoretically, the FDI can have positive to negative ecological consequences, depending on which transmission channel is more dominant. Putting it simply, whether, the pollution-haven hypothesis, the pollution-halo hypothesis, and/or the scale effects hypothesis prevails (Pao and Tsai, 2011). The empirical evidence suggests that in different countries and regions, FDI has shown to have different effects on environmental degradation. For instance, Pao and Tsai (2011) on BRICS, Al-Mulali and Tang (2013) on the GCC countries, Pazienza (2015a, b) on OECD countries, Zhang and Zhou (2016) on the Chinese regions, Liu et al. (2017) and Jiang et al. (2017) on Chinese cities reported that the FDI improves environmental quality. On the contrary, He (2006) and Ren et al. (2014) on China, Hitam and Borhan (2012) and Lau et al. (2014) on Malaysia, Tang and Tan (2015) on Vietnam, Paramati et al. (2016) on 20 developing countries,[4] Sbia et al. (2014) on Middle Eastern countries, Abdouli and Hammami (2017) on MENA, Shahbaz et al. (2015) on high, middle and low-income countries and Solarin et al. (2017) on Ghana and most recently, Shahbaz et al. (2018) focusing on France reported that the FDI leads to an increase in environmental degradation. In fact, there are a number of studies which reported insignificant impact, for instance, Kivyiro and Arminen (2014) on selected sub-Saharan countries and Lee (2013) on the G-20 countries. In fact, those studies which focused on some of the countries in the ASEAN region also reported mixed and contrasting results (contrast, Chandran and Tang (2013), Zhu et al. (2016), Baek (2015). Nonetheless, they also ignored the important aspect of financial development and economic growth which are required to be seen in conjunction with the FDI. To reiterate, we are also looking at financial development in a more inclusive manner. These factors add to the debate on the subject. Concomitantly, keeping the financial and economic development in the ASEAN region as well as a remarkable influx of FDI, the subject study is intended to investigate the ecological consequences of these developments. In so doing, we are employing a set of empirical approaches and in the next section, we elaborate on them.

3. Methodology

3.1. Cross-section dependence

Firstly, we attempt to evaluate the cross-sectional dependence among variables by following Pesaran (2004, 2007). To start with the equation as follows:

$$\Delta Y_{it} = \pi_i Y_{i,t-1} + \gamma_i Z_{it} + \sum_{j=1}^{p-1} \theta_{ij} Y_{i,t-j} + \varepsilon_{it} \quad (1)$$

In which, Z_{it} is a deterministic component and $\sum_{j=1}^{p-1} \theta_{ij} Y_{i,t-j}$ is considered as ADF test. Therefore, ε_{it} is cross-sectional for objects i when they share the common factors. By defining that, we have:

$$\varepsilon_{it} = \theta_i f_t + u_{it} \quad (2)$$

θ_i means that each individual has different impact and u_{it} considers as no cross-sectional and no autocorrelation.

By embedding Equation (2) into Equation (1), we have:

$$\Delta Y_{it} = \pi_i Y_{i,t-1} + \gamma_i Z_{it} + \sum_{j=1}^{p-1} \theta_{ij} Y_{i,t-j} + \theta_i f_t + u_{it} \quad (3)$$

Thereafter, we follow the Pesaran (2004) to test whether there is an existence of cross-sectional dependence among variables or not which is built the hypothesis: H_0: $\theta_i \neq 0$ and H_A: $\theta_i = 0$.

3.2. Stationarity test

Secondly, we elaborate on the test of stationarity based on Levin et al. (2002), Im et al. (2003) and Pesaran (2007). The general equation built by Levin et al. (2002) test can be specified as follows:

$$\Delta Y_{it} = \pi_i Y_{i,t-1} + \gamma_i Z_{it} + u_{it} \quad (4)$$

In which, u_{it} is white noise, then $u_{it} \sim N(0; \sigma^2)$. Then, the hypothesis for equation (4) having a unit root test against that Y_t is stationary. So, H_0: $\pi_i \neq 0$ and H_A: $\pi_i < 0$. The test of Levin et al. (2002) had been used to estimate the Augmented Dickey-Fuller regression on the pooled panel data by Ordinary Least Squares. However, the Im et al. (2003) develops the latter assumption, which corrects the drawbacks from the OLS approach by using varying autoregressive procedures across estimated individuals. Therefore, the results are known as group-mean of individual t-statistics with the following equation where i = 1, 2, …N and t = 1, 2 … T from the previous equation (4).

$$\bar{t}_{it} = i^{-1} \sum_{i=1}^{N} t_{iT}(\pi_i, \theta_{1i}, ..., \theta_{iP_i}) \quad (5)$$

Thereafter, we extract the terms of $(\pi_i, \theta_{1i}, ..., \theta_{iP_i})$ denotes the t-statistics for testing the unit root for the ith individual procedures (in which π_i – lagged order, normally used to select optimal lag order). Therefore, $\bar{t}_{it}$, which represents Im et al. (2003) test, is able to test the null hypothesis H_0: $\pi_i \neq 0\ \forall\ i$ against H_A: $\exists\ i\ \in \{1, ..., N\},\ \pi_i < 0$. Subsequently, for the existence of cross-sectional dependency, the CIPS (Cross-sectional IPS) is developed on the basis of Im et al. (2003). When IPS employs ADF, CIPS it uses cross-sectional ADF (called by CADF). The main concept of CIPS is to add the lagged cross-sectional value of mean of the individual $\overline{Y_t}$ to control the effects of the common factors. Hence, CIPS is quite popular to use for the existence of cross-sectional dependence. The other process of CIPS is similar to IPS except the existence of means of $\overline{Y_t}$ as the specific factors for cross-sectional dependency.

3.3. Cointegration test

Thirdly, we will discuss the methodologies used for testing whether the co-integration in panel data exists or not. The approach from co-integration test for panel data is mainly based on the following notion:

$$y_{it} = x'_{it}\beta_i + z'_{it}\gamma_i + e_{it} \quad (6)$$

The test is focused on the covariates in x_{it} are not co-integrated themselves. β_i denotes the vector conveying the co-integrating phenomenon, which might differ across panels. γ_i is a vector with coefficients on Z_{it}, which is known as deterministic terms to control panel-specific effects and linear time trends. e_{it} is error term, which should be in accordance with white noise $e_{it} \sim N(0; \sigma^2)$.

Kao (1999) indicates the assumptions of co-integrating vector from Equation (6) with $\beta_i = \beta$; therefore, the panels follow common slope coefficients. Thus, Kao (1999) proposes five kinds of test such as Modified Dickey-Fuller t, Dickey-Fuller t, Augmented Dickey-Fuller t, Unadjusted modified Dickey-Fuller t and Unadjusted Dickey-Fuller t from the Dickey-Fuller regression:

$$\hat{e}_{it} = \rho \hat{e}_{i,t-1} + \upsilon_{it} \quad (7)$$

In which, ρ is the common Auto Regression parameter of the estimated residuals. Meanwhile, the Augmented Dickey-Fuller regression is

[4] Brazil, China, Chile, Czech Republic, Colombia, Egypt, Greece, Hungary, Indonesia, India, Korea, Mexico, Malaysia, Peru, Poland, Philippines, Russia, South Africa, Turkey and Thailand.

given by

$$\hat{e}_{it} = \rho\hat{e}_{i,t-1} + \sum_{j=1}^{p} \rho_j \Delta\hat{e}_{i,t-j} + \upsilon_{it} \quad (8)$$

Interestingly, in this approach, ρ reflects the number of lagged difference terms. Noticeably, the asymptotic distribution for all Kao (1999) tests must be converged into N (0,1). *In contrast*, Pedroni (1999) evaluates each panel-specific co-integrating vector from Equation (6) has different individual slope coefficients. Then, the Pedroni (1999) test employs the unit root test of estimated residuals by Augmented Dickey-Fuller regression. However, the interesting thing is to allow each ρ_i instead of the same ρ (like Kao (1999)). In addition, this approach is considered to be following the convergence characteristics after appropriate standardization. Another co-integration test is employed by Westerlund (2005), which assumes that the specific co-integrating vectors have different individual slope coefficients. This test allows to perform well under the cross-sectional dependency and it is usually used as a robustness test. Additionally, Westerlund (2005) is normally used to deal with the problem raising by determining structural breaks endogenously.

3.4. Estimation: FMOLS (Fully Modified OLS) and DOLS (Dynamics OLS)

Finally, many previous studies proposed that the presence of co-integration should be referred to the two main methods such as OLS-based estimators—FMOLS (Fully Modified OLS) and DOLS (Dynamics OLS). The main difference between the two approaches is how to correct the autocorrelation in regression. FMOLS allows using Newey-West for correction whereas DOLS accepts to add more lagged and lead variables. Pedroni (1996, 2001) suggested the approach to estimate the coefficients, which is used to measure the long-run effects.

$$\hat{\beta}_{FMOLS} = \left(\sum_{i=1}^{N} \hat{L}_{22i}^{-1} \sum_{t=1}^{T} (x_{it} - \bar{x}_i)^2\right)^{-1} \sum_{i=1}^{N} \hat{L}_{11i}^{-1}\hat{L}_{22i}^{-1}\left(\sum_{t=1}^{T} (x_{it} - \bar{x}_i)y_{it}^{*} - T\hat{\delta}_i\right) \quad (9)$$

In which,

$$y_{it}^{*} = (y_{it} - \bar{y}_i) - \left(\frac{\hat{L}_{21i}}{\hat{L}_{22i}}\right)\Delta x_{it} + \left(\frac{\hat{L}_{21i} - \hat{L}_{22i}}{\hat{L}_{22i}}\right)\beta(x_{it} - \bar{x}_i) \quad (10)$$

and we denotes $\hat{\delta}_i$ as

$$\hat{\delta}_i \equiv \hat{\Gamma}_{21i} + \hat{\Omega}_{21i}^{0} - \left(\frac{\hat{L}_{21i}}{\hat{L}_{22i}}\right)(\hat{\Gamma}_{22i} + \hat{\Omega}_{22i}^{0}) \quad (11)$$

In order to clarify, we refer to Ω as asymptotic covariance matrix for long-run variance and Γ as dynamic covariance. In addition, L is a lower triangular matrix with partition calculation. Then, DOLS estimator is employed which takes the following form:

$$y_{it} = \beta_i' x_{it} + \sum_{j=-q}^{q} \zeta_{ij}\Delta x_{i,t+j} + \gamma_{li'}D_{li} + \varepsilon_{it} \quad (12)$$

In which, q is known as the numbers of leads/lags chosen for the models. Thereafter, DOLS estimator is referred to Kao and Chiang (2001) for using the finite sample properties.

3.5. Data

In this study, we choose five ASEAN countries which are also the largest economies of the ASEAN block. These include Singapore, Thailand, Malaysia, Philippines and Indonesia over the period from 1982 to 2014. The main reason to focus on these economies and the time period of 33 years is data availability from the World Bank and well-balanced data for cross-sectional with time-series data characteristics. There are seven variables used in this study and the description as well as sources of data are represented in Table 1 below.

For financial development, we took an inclusive approach. We chose three categories such as bank credit to bank deposit, the number of listed companies and international debt representing financial development and structure dataset. These are the components for the banking system, equity market and debt market, which reflect the ability for financial integration and development by each country. After data collection, we transformed the absolute value to the percentage change for each country. These five economies are supposed to advance and emerging economies, which is attracting scholars' attention.

Fig. 1 summarises the CO2 emission in the ASEAN region by World Bank Data Sources. In which, Malaysia is the country which lies into the group from 6.5 to 10.31 metric ton carbon dioxide in the ASEAN area. The remaining ones are categorized into one group with 2.77–6.50 metric ton.

3.6. Descriptive statistics

In order to gain some insight into the characteristics of the dataset, we performed the descriptive statistics analysis as presented in Table 2.

Based on the descriptive statistics, the value of skewness for all variables is positive and excess from zero. Hence, all variables have demonstrated the characteristics for skewness to the right. In addition, the excess kurtosis is greater than zero, implying that all variables' distributions experience the fat-tailed phenomenon. From the skewness and kurtosis findings, all variables are rejected to be normally distributed. The Jarque-Bera test subsequently confirmed the results. These findings support the notion to employ the set of quantitative techniques as manifested in the next section.

4. Empirical findings

4.1. Panel unit root test

Before the application of panel unit tests for stationarity of the variables, we tested whether a cross-sectional dependency exists or not. In so doing, we employ the Breusch and Pagan (1980), Pesaran (2004) and Frees (1995, 2004) tests and the results are in the following Table 3.

The results indicate the strength and existence of cross-sectional dependency. The null hypothesis proposed by these tests is no presence of cross-sectional dependency. It showed that only the Pesaran (2004) approach rejects this null hypothesis at a significance level of 10% whereas Breusch and Pagan (1980) fails to reject. Then, using Frees' Q-distribution (T-asymptotically distributed) based on the approach proposed by Frees (1995, 2004) also failed to reject the null hypothesis. Meanwhile, the Pesaran test is mainly based on standard normal distribution. With the analysis above, we evaluate that there is no cross-sectional dependence. Nevertheless, in order to be strongly convinced, we employ both the first and second-generation test for panel unit root tests, which might provide inferences that are more reliable. Basically, we employ multiple panel unit root tests to check whether our variables are stationary or not. These include Levin et al. (2002), Im et al. (2003) and Pesaran panel unit root test in the presence of cross-section dependence by Pesaran (2007). These approaches are abbreviated by LLC, IPS and CIPS, respectively. Although we pass through the cross-sectional dependency, we choose to consider for both cases.

With the strict assumption and a broad set of tests from LLC, IPS and CIPS, all variables are stationary at significance level 1%. Whether the presence of cross-sectional dependency exists or not, the findings in Table 4 assure that all panels have stationarity.

4.2. Co-integration analysis

In order to provide the co-integration analysis, we employ the Pedroni (1999, 2004) test to answer whether there is the existence of panel co-integration among our variables. The null hypothesis

Table 1
Data description.
Source: The author's collection

Variables	Explanation	Measurement	Source
CO_2	CO_2 emissions (metric tons per capita)	The amount of carbon dioxide emissions was calculated under the procedure of stemming from burning fossil fuel including solid, liquid, and gas fuels and gas flaring.	World Development Indicators
FDI	Foreign direct investment, net inflows (percentage of Gross Domestic Product)	There were net inflows computing by new investment inflows excluding disinvestment. This figure was divided by the total Gross Domestic Product	World Development Indicators
GDP	The annual percentage growth rate of GDP at market prices based on constant local currency.	GDP is the sum of gross value added by all resident producers in the economy plus any product taxes and minus any subsidies not included in the value of the products. Then we calculate the growth rate from the previous year.	World Development Indicators
Financial development and Structure Dataset are measured by a group of variables here			
BCBD	Bank credit to Bank Deposit (Percentage)	Private credit was retrieved by deposit money banks report; specifically, IFS line 22d, FOSAOP over the bank deposits was extracted from IFS lines 24, FOST, and 25, FOSD.	Čihák et al. (2012) The World Bank[a] International Monetary Fund[b]
Listco_pc	The number of listed companies per 10.000 population	Total number of listed companies was scaled by 10.000 population	World Development Indicators
Int. Debt	International debt issued over total Gross Domestic Product	The amount of outstanding of International Debt Securities was divided by total Gross Domestic Product	Bank for International Settlements World Development Indicators

[a] World Bank in Washington District of Columbia.
[b] International Monetary Fund in Washington District of Columbia.

Fig. 1. CO2 emission in the ASEAN region by World Bank Data Sources (Source: World Development Indicators).

Table 2
Descriptive statistics.

Variable	Mean	Std. Dev.	Skewness	Kurtosis	J-B
CO_2	0.034753	0.125603	1.020753	10.67684	433.8***
FDI	−0.12543	4.769969	−8.031189	91.36219	55000***
GDP	−0.29684	2.852479	−4.577124	45.89052	13000***
BCBD	−0.00248	0.086582	−0.7608297	8.23216	204.1***
Listco_pc	0.071519	0.348047	8.136386	84.77175	48000***
Int. Debt	0.127683	0.417534	2.527964	10.59441	572.3***

This table reports the summary statistics including mean, standard deviation (Std. Dev.), skewness, excess kurtosis, and Jarque-Bera (J-B) test. The symbols *, **, and *** denote the significance at the 10%, 5%, and 1% levels, respectively.

Table 3
Cross-section dependence tests.

Test	parameter	Results
Breusch-Pagan LM	14.623	Fail to reject null hypothesis
Pesaran	1.724*	Reject at significance level 10%
Frees' test	0.080	Fail to reject null hypothesis

The null hypothesis is that H_0: there is no cross-sectional dependence. Levels of significance: * p-value < 0.1, ** p-value < 0.05, *** p-value < 0.01.

postulates that there is no co-integration in all tests.

In Table 5 below, the majority of tests indicate rejection of the null hypothesis. This implies the presence of co-integration for both cases i.e. intercept as well as intercept and trend in the panel. We employ Kao (1999) test of no co-integration between a group of variables such as Co2, FDI, GDP, BCBD, Listco_pc and Int. Debt (see Table 6).

It is clearly seen that all tests following the Kao (1999) approach unanimously reject the null hypothesis of no cointegration. Therefore, we can conclude that there is co-integration phenomenon in our research variables. This finding is of high significance and provides strong evidence that the variables have a long run relationship.

A point to acknowledge at this juncture is that study by Hossfeld

Table 4
Unit root tests.

Variable	Test	Intercept	Intercept and Trend	Conclusion
CO_2	LLC	−4.9030***	−3.9189***	Stationary at significance level 1%
	IPS	−6.5278***	−6.8139***	
	CIPS	−4.942***	−5.168***	
FDI	LLC	−4.6187***	−4.0224***	Stationary at significance level 1%
	IPS	−6.8589***	−7.2387***	
	CIPS	−4.911***	−5.158***	
GDP	LLC	−7.4287***	−6.3610***	Stationary at significance level 1%
	IPS	−7.0490***	−7.2209***	
	CIPS	−5.752***	−5.804***	
BCBD	LLC	−5.1850***	−4.4493***	Stationary at significance level 1%
	IPS	−2.6765***	−2.9133***	
	CIPS	−2.715***	−2.896**	
Listco_pc	LLC	−3.9101***	−3.5697***	Stationary at significance level 1%
	IPS	−4.7903***	−5.2802***	
	CIPS	−3.881***	−3.915***	
Int. Debt	LLC	−3.8427***	−2.6557***	Stationary at significance level 1%
	IPS	−6.4860***	−6.3764***	
	CIPS	−5.148***	−5.057***	

The symbols *, **, and *** denote the significance at the 10%, 5%, and 1% levels, respectively. A Levin-Lin-Chu unit-root test, H_0: Panels contain unit roots and H_A: Panels are stationary. As regards Im-Pesaran-Shin unit-root test, H_0: All panels contain unit roots (or all the series are non-stationary) and H_A: Some panels are stationary. Regarding Pesaran Panel Unit Root Test with cross-sectional, H_0: homogeneous non-stationary (bi = 0 for all i); and H_A: stationary.

Table 5
Panel co-integration tests by Pedroni (1999, 2004).

Test-Statistics	Intercept	Intercept and Trend
Modified Phillips-Perron	−0.2944	0.4553
Phillips-Perron	−7.4660***	−7.5192***
Augmented Dickey-Fuller	−7.6316***	−7.3770***

The symbols *, **, and *** denote the significance at the 10%, 5%, and 1% levels, respectively. Null hypothesis is no co-integration between variables.

Table 6
Panel co-integration tests by Kao (1999).

Test-Statistics	Intercept	Subtract cross-sectional means
Modified Dickey-Fuller	−19.0069***	−15.7540***
Dickey-Fuller	−11.2485***	−11.1549***
Augmented Dickey-Fuller	−9.3509***	−9.4790***
Unadjusted modified Dickey-Fuller	−20.1251***	−20.4243***
Unadjusted Dickey-Fuller	−11.2720***	−11.4651***

The symbols *, **, and *** denote the significance at the 10%, 5%, and 1% levels, respectively. H_0: No co-integration and H_A: All panels are co-integrated.

(2010, p.16) indicates that it is necessary to test robustness if the different test by Pedroni (1999, 2004) generates different test statistics for the same test decision. The rationale of doing so comes from Monte Carlo simulations, which show various test-statistics relying on panel dimension and the assumed data generating process. It is very important to provide additional co-integration testing which proves the robustness for structural breaks and cross-sectional dependence. One of the reliable tests is Westerlund (2005) with the null hypothesis being no co-integration for all panels.

The results of Westerlund's tests presented in Table 7 suggest that based on the critical values generating from bootstrapped robust, there are three out of four tests which reject the null hypothesis. These findings further confirm that there is a long-run relationship among variables based on cointegration (see Table 9) (see Table 8).

Table 7
Westerlund Panel co-integration tests.

Test statistics	Value
Gt	−3.928***
Ga	−14.139
Pt	−9.097***
Pa	−16.509**

The symbols *, **, and *** denote the significance at the 10%, 5%, and 1% levels, respectively. The Ga and Gt test statistics are to test H_0: $a_i = 0$ for all i whereas the H_A: $a_i < 0$ for at least one i. In addition, the P_a and P_t test statistics implying pool information over all the cross-sectional units with H_0: $a_i = 0$ for all i whereas the H_A: $a_i < 0$ for at least one i.

Table 8
Estimation of co-integrating relationship by FMOLS (trend and non-trend).

Estimation method: Long-run coefficient	Fully Modified OLS	
	Trend	No-trend
FDI	−0.01	−0.01
	[-2.26]	[2.30]
GDP	0.01**	0.01**
	[2.25]	[2.20]
BCBD	0.26***	0.26***
	[6.25]	[6.23]
Listco_pc	0.17***	0.18***
	[2.97]	[2.77]
Int. Debt	−0.01	−0.01
	[-1.48]	[-1.96]

The symbols *, **, and *** denote the significance at the 10%, 5%, and 1% levels, respectively whereas t-statistics of the corresponding coefficients are reflected in square brackets.

Table 9
Estimation of co-integrating relationship by DOLS.

Estimation method: Long-run coefficient by Dynamic OLS	
FDI	0.03**
	[2.03]
GDP	−0.01
	[0.83]
BCBD	0.17
	[-1.03]
List co_pc	−0.002***
	[3.02]
Int. Debt	−0.04
	[0.19]

The symbols *, **, and *** denote the significance at the 10%, 5%, and 1% levels, respectively whereas t-statistics of the corresponding coefficients are reflected in square brackets.

4.3. Estimation

We choose two methodologies such as FMOLS (Fully Modified OLS) and Pooled-Mean Group (PMG) for estimating the long-run relationships for our variables. We choose FMOLS as our main approach because FMOLS employs the Newey-West to correct the autocorrelation of the error term U_{it}. However, if we choose lagged variables and lead variables in our models to control the errors of autocorrelation on the error term U_{it}, we have the choice of Dynamic OLS.

For both cases of trend and no-trend, there are three significant variables such as GDP, Bank credit (BCBD) and listed companies as a percentage of the population (listco_pc) which positively influence (at 5% and 1% significance level) the CO_2 emissions in five ASEAN economies. Hence, more financial development implies more carbon dioxide emissions. The credit creation in specific shows that a 1%

change in bank credit over bank deposit, on average, results in a 0.26% change in the level of carbon dioxide emission for our chosen economies in ASEAN. Moreover, it is also interpreted in the light of results that a 1% increase in the number of listed leads to the 0.17% and 0.18% increase in CO_2 emission with and without trend approaches, respectively. Interestingly, Int. Debt showed a negative impact on the CO_2 emission implying that there are significant differences in the impact of different aspects of financial development on the environment. Perhaps, not all forms of financial developments are bad! These findings, particularly by using listed companies and credit creation as measure of financial development are in line with the existing evidence on the subject which mostly focused on only the credit creation and on other countries which suggested a positive link between finance and environmental degradation (Sadorsky, 2010, 2011; Shahbaz et al., 2012a, 2013c, 2017c, 2018, 2012b; Islam et al., 2013; Katircioglu and Taspinar, 2017; Cetin and Ecevit, 2017).

The results on FDI showed a negative impact of FDI on environmental degradation. These finding were in line with the study by Pao and Tsai (2011) on BRICS, Al-Mulali and Tang (2013) on the GCC countries, Pazienza (2015a an 2015b) on OECD countries, Zhang and Zhou (2016) on the Chinese regions, Liu et al. (2017) and Jiang et al. (2017) on Chinese cities reported that the FDI improves environmental quality. However, the findings are contrary to the study by He (2006) and Ren et al. (2014) on China, Hitam and Borhan (2012) and Lau et al. (2014) on Malaysia, Tang and Tan (2015) on Vietnam, Paramati et al. (2016) on 20 developing countries, Sbia et al. (2014) on Middle Eastern countries, Abdouli and Hammami (2017) on MENA, Shahbaz et al. (2015) on high, middle and low-income countries and Solarin et al. (2017) on Ghana and most recently, Shahbaz et al. (2018) on France which reported that the FDI leads to an increase in environmental degradation. Additionally, the results apparently indicate the existence of the long-term co-integration relationship between CO_2 emissions and economic growth (GDP) that is also statistically significant. When the GDP rises 1%, which only contributes to a 0.01% increase in CO_2 emission. The findings are in line with the studies by Tiwari et al. (2013) and Sinha and Shahbaz (2018) but contradict the results by Ghosh (2010) which failed to establish a long-run relationship between economic growth and emissions. Noticeably, the GDP growth causes the level of CO_2 emission less than the financial development does, which prima facie evident in the magnitude of coefficients.

The application of Dynamic OLS yielded results which were different from those obtained by the Fully Modified OLS. The 'FDI' is turned out to be a major factor causing CO_2 emission at significance level 5%. Specifically, it showed that a 1% increase in FDI will cause 0.03% increase in CO_2 emission. This finding is quite reasonable because foreign direct investment is expected to contribute to the level of carbon dioxide by building many plants as well as factories in the ASEAN region. Another considerable estimation is the number of listed companies, it showed negative impact implying that financial development through equity market proves to be more environment friendly as it decreases CO_2 emission. Specifically, if the number of listed companies increases by 1%, the CO_2 emission will decrease by 0.002% at 1% level of significance. This finding is in contrast to the previous estimation by Fully Modified OLS. The main reason for this difference is a method to solve autocorrelation by using lagged and lead variables. The parameters generated by OLS differ from the ones of FMOLS estimator because the requirements of DOLS is no initial estimation and non-parametric correction. Therefore, Kao and Chiang (2001) indicate that DOLS outperforms FMOLS approach. Not only is DOLS computationally simpler but it also avoids biased errors better than FMOLS. Hence, by employing this methodology, we can investigate the existence of a relationship between FDI and CO_2 emission.

4.4. Estimation of Environmental Kuznets curve

In order to analyse the long run impact of economic growth on environmental degradation, we add the quadratic of GDP i.e. GDP^2. Table 10 here shows the relationship by two different methodologies in long-run estimation including FMOLS and DOLS (see Table 11).

Table 10
Environmental Kuznets curve, FMOLS & DOLS estimation.

Estimation method: Long-run coefficient	Estimation	
	FMOLS	DOLS
FDI	−0.01	0.04
	[-2.42]	[0.52]
GDP^2	−0.0009	−0.0009
	[-5.51]	[0.48]
GDP	0.01***	0.02**
	[2.95]	[1.86]
BCBD	0.19***	0.09
	[4.60]	[-0.87]
Listco_pc	0.19***	−0.22***
	[3.09]	[4.01]
Int. Debt	−0.01	−0.13**
	[-1.58]	[1.72]

The symbols *, **, and *** denote the significance at the 10%, 5%, and 1% levels, respectively whereas t-statistics of the corresponding coefficients are reflected in square brackets.

The rest of the results are similar to the previous findings in the model without quadratic of GDP. It showed that one per cent increase in GDP will trigger 0.01% (at 1% significance level) and 0.02% (at 5% significance level) in CO_2 emission by Fully Modified OLS and Dynamic OLS respectively. In the FMOLS model, the ratio of bank credit and bank deposit have a positive relationship with CO_2 emission at 1% significance level. Similarly, the number of listed companies are contrasted in two different methodologies. This shows a positive coefficient in FMOLS whereas the coefficient in DOLS is negative. Both cases are significant at 1%. More interestingly, the international debt is a new finding in this model. This factor generates the negative coefficient in DOLS at significance level of 5%. This means that one per cent increase in international debt will decrease by 0.13% in the level of carbon dioxide emission at significance level of 5%. Most importantly, the coefficients of GDP^2 is showed a negative sign indicating the presence of the Environmental Kuznets curve, however, the results were not statistically significant. The findings can be contrasted against study by Fosten et al. (2012) on the UK, Esteve and Tamarit (2012) and Sephton and Mann (2013) on Spain, Brajer et al (2009) on China, Apergis (2016) on OECD countries, Al-Mulali and Ozturk (2016) on 27 developed countries which found the evidence of EKC as well studies by Pal and Mitra (2017) on India and China, Baek (2015) on Arctic countries, Caviglia-Harris et al. (2009) on 40 countries and Özokcu and Özdemir (2017) on 52 developing and 26 OECD countries which reported that there is no significant evidence of EKC. Perhaps, it is cogent to recognise the argument by Shahbaz and Sinha (2019) the results of EKC are contingent on the contexts, time period, explanatory factors and as well as empirical approach and economies in question. In specific to the subject economies, this implied that the continued economic growth in the ASEAN in its own steam shall be expected to harbour environmental improvements.

4.5. Robustness test (white noise test for residuals)

Considering that fact that there are some contrasting results (signs of 'Listco_pc') in different models, we decided to test the validity and robustness of our model. Thus, we extract the residuals in all the long-term relationships and test for white noise to ensure that our model is not spurious.

Based on the results of the white noise test for each model, we can hereby confirm that all of the residuals are white noise with iid $(0, \sigma^2)$. Therefore, our regression results are unbiased and consistent and the

Table 11
White noise test for residuals.

Models	White noise test statistics	Results
CO_2 emission (fdi, gdp, bcbd, listco_pc, intldebt) by FMOLS	48.6358	Fail to reject Residual is white noise
CO_2 emission (fdi, gdp, bcbd, listco_pc, intldebt) by DOLS	22.9067	Fail to reject Residual is white noise
CO_2 emission (fdi, gdp2, gdp, bcbd, listco_pc, intldebt) by FMOLS	27.6095	Fail to reject Residual is white noise
CO_2 emission (fdi, gdp2, gdp, bcbd, listco_pc, intldebt) by DOLS	48.2601	Fail to reject Residual is white noise

Null hypothesis for time series $\{x_t\}$ or set of residual $\{r_t\}$ is iid $(0, \sigma^2)$ or White noise $(0, \sigma^2)$. The symbols *, **, and *** denote the significance at the 10%, 5%, and 1% levels.

model is not spurious.[5] The empirical results lead us to conclude.

5. Conclusion & policy implications

In the last few decades in general, and particularly since the Global Financial Crisis, the emerging economies from Asia have acted as a locomotive of global growth. In this context, the ASEAN region has emerged as a crucial player with rapid economic and financial growth as well as attracting an unprecedented inflow of foreign direct investment. While these economic and financial developments are appreciable in the monetary sense, it is cogent to look at the ecological consequence of these factors for the emerging ASEAN. Contextualising on these backgrounds and motivating factors in this study we analysed the ecological implication of the economic growth, financial development and FDI for the ASEAN economies. In this endeavour, we drew on the historical dataset from 1982 to 2014 and employed a broad set of quantitative techniques for panel analysis which entailed Dynamic Ordinary Least Squares (DOLS) and Fully Modified OLS (FMOLS) approaches. Our results perspicuously demonstrate the existence of a statistically significant long-term relationship between CO_2 emission and foreign direct investment, gross domestic product, financial development (bank credit over bank deposit and the number of listed companies in equity markets). The only aspect of financial development where we could not find significant ecological implication was international debt which did not show a strong relationship with carbon dioxide emission. This was intuitive and cogent and implied that the domestic credit creation is rather more influential on the environmental degradation in the long run.

Our empirical results also lead us to conclude that the economic growth and increase in the FDI leads to an increase in environmental degradation in the ASEAN economies. Hence, the rapid economic growth and foreign direct investment which has been observed in the last few decades and expected to continue will have negative ecological consequences. There is significant evidence of Pollution Heaven Hypothesise (PHH). There is also evidence of the Environmental Kuznets Curve (EKC) in the ASEAN economies as the quadratic term for GDO was found to have a negative impact. However, the results were not statistically significant implying that the continuous growth under its own steam shall not harbour environmental sustainability. This also has crucial policy implications and manifestations of active policy responses for more inclusive and sustainable growth. In terms of financial development in ASEAN economies, the evidence on hand indicates that the increase in credit creation by the banking sector (bank credit over bank deposit) adversely affects the environment. This is intuitive as the banking credit system is mainly used to foster the lending channel for industries, which are not 'green' but are engaged in intensive 'energy consumption'. The financial development in terms of capital market development brought us interesting and contrasting results. We found contrasting results for the capital market expansion (the number of listed companies) on CO_2 emission. Especially, the estimates by FMOLS indicates a positive impact, yet the estimates provided by the DOLS indicated a negative impact on environmental degradation. At this juncture, given the fact that the estimates by the DOLS are more robust against bias, we conclude that this measure of financial development i.e. the number of listed companies will decrease the level of CO_2 emissions. In a nutshell, we conclude that rapid economic growth and FDI can have unintended ecological consequences for the ASEAN economies. In the policy context and particularly with regards to the Sustainable Development Goals (SDGs), it is vital to focus on the more sustainable economic growth by allocating resources to environment friendly sectors of the economy. The specific aspect of SDGs which are directly relevant are the promotion of sustained, inclusive and sustainable economic growth, ensuring the sustainable production and consumption patterns and most importantly the actions to combat climate change and its impact by regulating emissions and promoting developments in renewable energy. The presence of weak evidence on EKC reflects the importance of active policy responses. It is also advisable to direct the flows of FDI into more sustainable and greener sectors of the economy to facilitate the relevant aspects of SDGs. In terms of financial development, it is also vital to allocate the financial resources to the environmental friendly sectors of the economy and hence, green finance is the way forward for the emerging ASEAN.

In this study we focused on the CO_2 emissions due to their ecological and environmental significance, however, for further research we propose that the framework of the subject study can be extended by the inclusion of the Ecological footprints in the analysis. Further research may also include the regulatory aspect and role of innovations and R & D in the renewable sectors of the ASEAN region, to overcome the adverse and unintended consequences of the subject factors.

[5] In order to further test the robustness of our estimates we employed the alternative estimation approaches including the Augmented Mean Group (AMG) and Common Correlated Effects Mean Group (CCEMG) estimators (See, Eberhardt and Bond, 2009; Eberhardt and Teal (2010); and Pesaran (2006). The results are in line with the estimation by DOLS and FMOLS. To preserve the space the estimations' by AMG and CCEMG are not reported here but are available on request.

Acknowledgement

This research is fully funded by the University of Economics Ho Chi Minh City.

References

Abbasi, F., Riaz, K., 2016. CO2 emissions and financial development in an emerging economy: an augmented VAR approach. Energy Policy 90, 102–114.
Abdouli, M., Hammami, S., 2017. Investigating the causality links between environmental quality, foreign direct investment and economic growth in MENA countries. Int. Bus. Rev. 26, 264–278.
Ackerman, F., 2017. Worst-Case Economics: Extreme Events in Climate and Finance. Anthem Press, New York, NY 2017.
Al-Mulali, U., Ozturk, I., 2016. The investigation of environmental Kuznets curve hypothesis in the advanced economies: the role of energy prices. Renewable & Sustainable Energy Reviews 54, 1622–1631.
Al-Mulali, U., Tang, C.F., 2013. Investigating the validity of pollution haven hypothesis in the gulf cooperation council (GCC) countries. Energy Policy 60, 813–819.
Apergis, N., 2016. Environmental Kuznets curves: new evidence on both panel and country-level CO2 emissions. Energy Econ. 54, 263–271.
ASEAN Investment Report, 2018. ASEAN Investment Report 2018, Foreign Direct Investment and the Digital Economy in ASEAN. available at: https://asean.org/asean-investment-report-2018-published/ accessed on 15th December 2018.
Atasoy, B.S., 2017. Testing the environmental Kuznets curve hypothesis across the U.S.: evidence from panel mean group estimators. Renew. Sustain. Energy Rev. 77,

731–747.
Baek, J., 2015. Environmental Kuznets curve for CO2 emissions: the case of Arctic countries. Energy Econ. 50, 13–17.
Bagehot, W., 1873. Lombard Street: A Description of the Money Market. London: John Murray, Reprinted with Introduction by Hartley Withers. William Clowes and Sons, London 1924 (1873).
Beck, T., 2012. Finance and Growth: Lessons from the Literature and the Recent Crisis, July 2012. Prepared for the LSE Growth Commission.
Bekhet, H.A., Matar, A., Yasmin, T., 2017. CO2 emissions, energy consumption, economic growth, and financial development in GCC countries: dynamic simultaneous equation models. Renew. Sustain. Energy Rev. 70, 117–132.
Borio, C., 2011. Rediscovering the Macroeconomic Roots of Financial Stability Policy: Journey, Challenges and a Way Forward. BIS Working Paper No. 354.
Brajer, V., Mead, R.W., Xiao, F., 2009. Health benefits of tunneling through the Chinese environmental Kuznets curve (EKC). Ecol. Econ. 66 (4), 674–686.
Breusch, T.S., Pagan, A.R., 1980. The lagrange multiplier test and its applications to model specification in econometrics. Rev. Econ. Stud. 47 (1), 239–253.
Campiglio, E., 2016. Beyond carbon pricing: the role of banking and monetary policy in financing the transition to a low-carbon economy. Ecol. Econ. 121, 220–230.
Caviglia-Harris, J.L., Chambers, D., Kahn, J.R., 2009. Taking the "U" out of Kuznets: a comprehensive analysis of the EKC and environmental degradation. Ecol. Econ. 68 (4), 1149–1159.
Cetin, M., Ecevit, E., 2017. The impact of financial development on carbon emissions under the structural breaks: empirical evidence from Turkish economy. Int. J. Econom. Perspect. 11 (1), 64–78 2016.
Chandran, V.G.R., Tang, C.F., 2013. The impacts of transport energy consumption, foreign direct investment and income on CO2 emissions in ASEAN-5 economies. Renew. Sustain. Energy Rev. 24, 445–453.
Chang, S.C., 2015. Effects of financial developments and income on energy consumption. Int. Rev. Econ. Financ. 35, 28–44.
Charfeddine, L., Khediri, K.B., 2016. Financial development and environmental quality in UAE: cointegration with structural breaks. 55. Renewable & Sustainable Energy Reviews, pp. 1322–1335.
Čihák, M., Demirgüç–Kunt, A., Feyen, E., Levine, R., 2012. Benchmarking financial development around the world, Electronic resource. 6175. World Bank Policy Research Working Paper, pp. 58.
Çoban, S., Topcu, M., 2013. The nexus between financial development and energy consumption in the EU: a dynamic panel data analysis. Energy Econ. 39, 81–88.
Cole, M.A., Fredriksson, P.G., 2009. Institutionalized pollution havens. Ecol. Econ. 68 (4), 1239–1256.
Das, K., Lin, D.Y., 2018. Asean States Have Fared Well. Now, to Continue Doing So. McKinsey & Company Home, McKinsey Global Institute available at: https://www.mckinsey.com/mgi/overview/in-the-news/asean-states-have-fared-well-now-to-continue, Accessed date: 7 December 2018.
Dogan, E., Seker, F., 2016. The influence of real output, renewable and non-renewable energy, trade and financial development on carbon emissions in the top renewable energy countries. Renew. Sustain. Energy Rev. 60, 1074–1085.
Eberhardt, M., Bond, S., 2009. Cross-section Dependence in Nonstationary Panel Models: A Novel Estimator. University Library of Munich MPRA Paper 17692. http://mpra.ub.uni-muenchen.de/17692.pdf.
Eberhardt, M., Teal, F., 2010. Productivity Analysis in Global Manufacturing Production. Department of Economics, University of, Oxford Discussion Paper 515.
Esteve, V., Tamarit, C., 2012. Is there an environmental Kuznets curve for Spain? Fresh evidence from old data. Econ. Modell. 29, 2696–2703.
FocusEconomics, 2018. Economic Forecasts from the World's Leading Economists, Economic Snapshot for ASEAN. available at. https://www.focus-economics.com/regions/asean.
Fosten, J., Morley, B., Taylor, T., 2012. Dynamic misspecification in the environmental Kuznets curve: evidence from CO2 and SO2 emissions in the United Kingdom. Ecol. Econ. 76, 25–33.
Frees, E.W., 1995. Assessing cross-sectional correlations in panel data. J. Econom. 69, 393–414.
Frees, E.W., 2004. Longitudinal and Panel Data: Analysis and Applications in the Social Sciences. Cambridge University Press, Cambridge.
Ghosh, S., 2010. Examining carbon emissions economic growth nexus for India: a multivariate cointegration approach. Energy Policy 38, 3008–3014.
Goldsmith, R.W., 1969. Financial Structure and Development. Yale University Press, New Haven.
Grafton, R.Q., Jotzo, F., Wasson, M., 2004. Financing sustainable development: country undertakings and rights for environmental sustainability CURES. Ecol. Econ. 51 (1–2), 65–78.
Grossman, G.M., Krueger, A.B., 1991. Environmental Impacts of a North American Free Trade Agreement. National Bureau of Economic Research Working Paper 3914, NBER, Cambridge MA. https://doi.org/10.3386/w3914.
Gurley, J., Shaw, E., 1960. Money in a Theory of Finance. Brookings, Washington.
He, J., 2006. Pollution haven hypothesis and environmental impacts of foreign direct investment: the case of industrial emission of sulfur dioxide (SO2) in Chinese provinces. Ecol. Econ. 60 (1), 228–245.
Hitam, M.B., Borhan, H.B., 2012. FDI, growth and the environment: impact on quality of life in Malaysia. Procedia Soc. Behav. Sci. 50, 333–342.
Hossfeld, O., 2010. Equilibrium Real Effective Exchange Rates and Real Exchange Rate Misalignments: Time Series vs. Panel Estimates FIW Working. Paper No. 65. Available online: https://www.econstor.eu/bitstream/10419/121070/1/N_065.pdf.
Im, K.S., Pesaran, M.H., Shin, Y., 2003. Testing for unit roots in heterogeneous panels. J. Econ. 115, 53–74.
Islam, F., Shahbaz, M., Ahmed, A.U., Alam, M.M., 2013. Financial development and energy consumption nexus in Malaysia: a multivariate time series analysis. Econ. Modell. 30, 435–441.
Jalil, A., Feridun, M., 2011. The impact of growth, energy and financial development on the environment in China: a cointegration analysis. Energy Econ. 33, 284–291.
Javid, M., Sharif, F., 2016. Environmental Kuznets curve and financial development in Pakistan. Renew. Sustain. Energy Rev. 54, 406–414.
Jiang, L., Zhou, H.-F., Bai, L., Zhou, P., 2017. Does foreign direct investment drive environmental degradation in China? An empirical study based on air quality index from a spatial perspective. J. Clean. Prod. 1–9.
Kao, C., 1999. Spurious regression and residual-based tests for cointegration in panel data. J. Econom. 90, 1–44.
Kao, C., Chiang, M.H., 2001. On the estimation and inference of a cointegrated regression in panel data. In: Nonstationary Panels, Panel Cointegration, and Dynamic Panels. Emerald Group Publishing Limited, pp. 179–222.
Katircioglu, S., 2012. Financial development, international trade and economic growth: the case of sub-saharan Africa. Ekonomista 15 (1), 117–127.
Katircioglu, S.T., Taspinar, N., 2017. Testing the moderating role of financial development in an environmental Kuznets curve: empirical evidence from Turkey. Renew. Sustain. Energy Rev. 68 (1), 572–586.
Kindleberger, C.P., 1978. Manias, Panics, and Crashes: A History of Financial Crises. Macmillan, London.
Kivyiro, P., Arminen, H., 2014. Carbon dioxide emissions, energy consumption, economic growth, and foreign direct investment: causality analysis for Sub-Saharan Africa. Energy 74, 595–606.
Lantz, V., Feng, Q., 2006. Assessing income, population, and technology impacts on CO2 emissions in Canada: where's the EKC? Ecol. Econ. 57 (2), 229–238.
Lau, L.S., Choong, C.K., Eng, Y.K., 2014. Investigation of the environmental Kuznets curve for carbon emissions in Malaysia: do foreign direct investment and trade matter? Energy Policy 68, 490–497.
Lee, J.W., 2013. The contribution of foreign direct investment to clean energy use, carbon emissions and economic growth. Energy Policy 55, 483–489.
Leimbach, M., Roming, N., Schultes, A., Schwerhoff, G., 2018. Long-term development perspectives of sub-saharan Africa under climate policies. Ecol. Econ. 144, 148–159.
Levin, A., Lin, C.-F., Chu, C.-S.J., 2002. Unit root tests in panel data: Asymptotic and finite-sample properties. J. Econ. 108, 1–24.
Lindmark, M., 2002. An EKC-pattern in historical perspective: carbon dioxide emissions, technology, fuel prices and growth in Sweden 1870–1997. Ecol. Econ. 42 (1–2), 333–347.
Liu, Y., Hao, Y., Gao, Y., 2017. The environmental consequences of domestic and foreign investment: evidence from China. Energy Policy 108, 271–280.
McKinnon, R.I., 1973. Money and Capital in Economic Development. Brooking Institution, Washington D.C.
Minsky, H.P., 1974. The modeling of financial instability: an introduction. In: Modeling and Simulation, Conference Proceedings of the Fifth Annual Pittsburgh Conference, Pittsburgh.
Minsky, H.P., 1982. The federal reserve between a rock and a hard place. In: Can it Happen Again? Essay on Instability and Finance, pp. 192–202 M.E. Sharpe, Armonk, NY.
Narayan, P.K., Narayan, S., 2010. Carbon dioxide emissions and economic growth: panel data evidence from developing countries. Energy Policy 38, 661–666.
Nasir, M., Ahmed, F., Ahmed, M., Wu, J., 2015. Financial and economic stability as 'two sides of a coin': non-crisis regime evidence from the UK based on VECM. J. Financial Econ. Policy 7, 327–353.
Naughton, H.T., 2014. To shut down or to shift: multinationals and environmental regulation. Ecol. Econ. 102, 113–117.
Nguyena, Y.N., Brown, K., Skully, M., 2017. Economic Development Levels and the Finance and Growth Nexus. Annual Meeting American Economics Association, Chicago, IL (January 6-8, 2017). Available at: https://www.aeaweb.org/conference/2017/preliminary.
Omri, A., Daly, S., Rault, C., Chaibi, A., 2015. Financial development, environmental quality, trade and economic growth: what causes what in MENA countries. Energy Econ. 48, 242–252.
Onafowora, O.A., Owoye, O., 2014. Bounds testing approach to analysis of the environment Kuznets curve hypothesis. Energy Econ. 44, 47–62.
Özokcu, S., Özdemir, Ö., 2017. Economic growth, energy, and environmental Kuznets curve. Renewable & Sustainable Energy Reviews 72, 639–647.
Ozturk, I., Acaravci, A., 2013. The long-run and causal analysis of energy, growth, openness and financial development on carbon emissions in Turkey. Energy Econ. 36, 262–267.
Pal, D., Mitra, S.K., 2017. The environmental Kuznets curve for carbon dioxide in India and China: growth and pollution at crossroad. J. Policy Model. 39, 371–385.
Pao, H.-T., Tsai, C.-M., 2011. Multivariate Granger causality between CO2 emissions, energy consumption, FDI (foreign direct investment) and GDP (gross domestic product): evidence from a panel of BRIC (Brazil, Russian Federation, India, and China) countries. Energy 36, 685–693.
Paramati, S.R., Ummalla, M., Apergis, N., 2016. The effect of foreign direct investment and stock market growth on clean energy use across a panel of emerging market economies. Energy Econ. 56, 29–41.
Pazienza, P., 2015a. The relationship between CO2 and foreign direct investment in the agriculture and fishing sector of OECD countries: evidence and policy considerations. Intellect. Econ. 9, 55–66.
Pazienza, P., 2015b. The environmental impact of the FDI inflow in the transport sector of OECD countries and policy implications. Int. Adv. Econ. Res. 21, 105–116.
Pedroni, P., 1996. Fully Modified OLS for Heterogeneous Cointegrated Panels and the Case of Purchasing Power Parity; Manuscript. Department of Economics, Indiana University Available online: http://web.williams.edu/Economics/pedroni/WP-96-

20.pdf.
Pedroni, P., 1999. Critical values for cointegration tests in heterogeneous panels with multiple regressors. Oxf. Bull. Econ. Stat. 61, 653–670.
Pedroni, P., 2001. Fully modified OLS for heterogeneous cointegrated panels. In: Baltagi, B.H., Fomby, T.B., Hill, R.C. (Eds.), Nonstationary Panels, Panel Cointegration, and Dynamic Panels; Advances in Econometrics. vol. 15. Emerald Group Publishing Limited, pp. 93–130.
Pedroni, P., 2004. Panel cointegration: asymptotic and finite sample properties of pooled time series tests with an application to the PPP hypothesis. Econom. Theor. 20, 597–625.
Pesaran, M.H., 2004. General Diagnostic Tests for Cross Section Dependence in Panels. University of Cambridge, Faculty of Economics Cambridge Working Papers in Economics No. 0435.
Pesaran, M.H., 2006. Estimation and inference in large heterogeneous panels with a multifactor error structure. Econometrica 74, 967–1012.
Pesaran, M.H., 2007. A simple panel unit root test in the presence of cross-section dependence. J. Appl. Econ. 22, 265–312.
Raworth, K., 2017. Doughnut Economics: Seven Ways to Think like a 21st-Century Economist. Random House Business978-1847941374.
Ren, S., Yuan, B., Ma, X., Chen, X., 2014. International trade, FDI (Foreign Direct Investment) and embodied CO2 emissions: a case study of Chinas industrial sectors. China Econ. Rev. 28, 123–134.
Rezza, A.A., 2013. FDI and pollution havens: evidence from the Norwegian manufacturing sector. Ecol. Econ. 90, 140–149.
Richardson, R.B., 2018. Book Review: Worst-Case Economics: Extreme Events in Climate and Finance, Frank Ackerman. 2017. Anthem Press, New York, NY (USA), 978-1783087075pp. 208 Ecological Economics, 150, pp. 361–362.
Sadorsky, P., 2010. The impact of financial development on energy consumption in emerging economies. Energy Policy 38, 2528–2535.
Sadorsky, P., 2011. Financial development and energy consumption in Central and Eastern European frontier economies. Energy Policy 39, 999–1006.
Salahuddin, M., Alam, K., Ozturk, I., Sohag, K., 2018. The effects of electricity consumption, economic growth, financial development and foreign direct investment on CO2 emissions in Kuwait. Renew. Sustain. Energy Rev. 81 2002–2010.
Sbia, R., Shahbaz, M., Hamdi, H., 2014. A contribution of foreign direct investment, clean energy, trade openness, carbon emissions and economic growth to energy demand in UAE. Econ. Modell. 36, 191–197.
Sephton, P., Mann, J., 2013. Further evidence of an environmental Kuznets curve in Spain. Energy Econ. 36, 177–181.
Shafik, N., 1994. Economic development and environmental quality: an Econometric analysis. Oxf. Econ. Pap. 46, 757–773.
Shahbaz, M., Sinha, A., 2019. Environmental Kuznets curve for CO2 emissions: a literature survey. J. Econ. Stud. 46 (1), 106–168.
Shahbaz, M., Lean, H.H., Shabbir, M.S., 2012a. Environmental Kuznets curve hypothesis in Pakistan: cointegration and Granger causality. Renew. Sustain. Energy Rev. 16, 2947–2953.
Shahbaz, M., Zeshan, M., Afza, T., 2012b. Is energy consumption effective to spur economic growth in Pakistan? New evidence from bounds test to level relationships and Granger causality tests. Econ. Modell. 29, 2310–2319.
Shahbaz, M., Tiwari, A.K., Nasir, M., 2013c. The effects of financial development, economic growth, coal consumption and trade openness on CO2 emissions in South Africa. Energy Policy 61, 1452–1459.
Shahbaz, M., Nasreen, S., Abbas, F., Anis, O., 2015. Does foreign direct investment impede environmental quality in high-, middle-, and low-income countries? Energy Econ. 51, 275–287.
Shahbaz, M., Shahzad, S.J.H., Ahmad, N., Alam, S., 2016a. Financial development and environmental quality: the way forward. Energy Policy 98, 353–364.
Shahbaz, M., Jam, F.A., Bibi, S., Loganathan, N., 2016b. Multivariate granger causality between CO2 emissions, energy intensity and economic growth in Portugal: evidence from cointegration and causality analysis. Technol. Econ. Dev. Econ. 22, 47–74.
Shahbaz, M., Omay, T., Roubaud, D., 2017. The Sharp and smooth breaks unit root testing of renewable energy consumption: the way forward. In: Paper Presented in 1st International Conference on Energy, Finance and the Macroeconomy, 22–24 November 2017. Montpellier Business School, Montpellier, France.
Shahbaz, M., Nasir, M.A., Roubaud, D., 2018. Environmental degradation in France: the effects of FDI, financial development, and energy innovations. Energy Econ. 74, 843–857.
Shaw, E.S., 1973. Financial Deepening in Economic Development. Oxford University Press, New York.
Sinha, A., Shahbaz, M., 2018. Estimation of environmental Kuznets curve for CO2 emission: role of renewable energy generation in India. Renew. Energy 119, 703–711.
Sinha, A., Shahbaz, M., Balsalobre, D., 2017. Exploring the relationship between energy usage segregation and environmental degradation in N-11 countries. J. Clean. Prod. 168, 1217–1229.
Solarin, S.A., Al-Mulali, U., Musah, U., Ozturk, I., 2017. Investigating the pollution haven hypothesis in Ghana: an empirical investigation. Energy 124, 706–719.
Song, M.-L., Zhang, W., Wang, S.H., 2013. Inflection point of environmental Kuznets curve in Mainland China. Energy Policy 57, 14–20.
Soukhakian, B., 2007. Financial development, trade openness and economic growth in Japan: evidence from granger causality tests. Int. J. Econom. Perspect. 1 (3), 118–127.
Soukhakian, N., 2007. Financial development and economic growth in Iran: evidence from Co-integration and causality tests. Int. J. Econom. Perspect. 1 (2), 56–63.
Tamazian, A., Rao, B.B., 2010. Do economic, financial and institutional developments matter for environmental degradation? Evidence from transitional economies. Energy Econ. 32, 137–145.
Tamazian, A., Chousa, J.P., Vadlamannati, K.C., 2009. Does higher economic and financial development lead to environmental degradation: evidence from BRIC countries. Energy Policy 37, 246–253.
Tang, C.F., Tan, B.W., 2015. The impact of energy consumption, income and foreign direct investment on carbon dioxide emissions in Vietnam. Energy 79, 447–454.
Tiwari, A.K., Shahbaz, M., Hye, Q.M.A., 2013. The environmental Kuznets curve and the role of coal consumption in India: cointegration and causality analysis in an open economy. Renew. Sustain. Energy Rev. 18, 519–527.
Westerlund, J., 2005. New simple tests for panel cointegration. Econom. Rev. 24, 297–316.
Yuan, F., Gallagher, K.P., 2018. Greening development lending in the americas: trends and determinants. Ecol. Econ. 154, 189–200.
Zhang, Y.J., 2011. The impact of financial development on carbon emissions: an empirical analysis in China. Energy Policy 39, 2197–2203.
Zhang, C., Zhou, X., 2016. Does foreign direct investment lead to lower CO2 emissions? Evidence from a regional analysis in China. Renew. Sustain. Energy Rev. 58, 943–951.
Zhu, H., Duan, L., Guo, Y., Yub, K., 2016. The effects of FDI, economic growth and energy consumption on carbon emissions in ASEAN-5: evidence from panel quantile regression. Econ. Modell. 58, 237–248.